SYNOPSIS

KEY POINT SUMMARY

OBJECTIVES

The objective of this paper was to explore airflow characteristics in a naturally cross-ventilated Nightingale ward, to measure ventilation rates and the potential for infection.

Measurement of ventilation and airborne infection risk in large, naturally ventilated hospital wards

Gilkeson, C.A., Camargo-Valero, M.A., Pickin, L.E., & Noakes, C.J. 2013 | *Building and Environment*. Volume 65, Pages 35-48

Key Concepts/Context

In healthcare environments, the transmission of airborne pathogens is a matter of concern. Ventilation has been identified as one of the key factors in the risk of infection. The authors indicate that most of the evidence on ventilation and infection risk has been in controlled spaces like operating rooms and isolation rooms, and that naturally ventilated spaces like wards have not been studied. They conducted a series of experiments in an unused ward to measure the transmission of pathogens in conditions of natural ventilation, mechanical ventilation, and no ventilation. They found that poor ventilation fosters the transmission of pathogens. This was a concern for ward environments that rely on natural ventilation, as winter conditions require the shutting of windows. They also found that cross-ventilation in wards is an effective means to control the travel of pathogens, and that partitions in wards decrease the exposure of most patients to the pathogens as compared to a ward with an open layout.

Methods

This was an experimental study carried out in an unoccupied former hospital ward in Bradford, UK. The ward had two types of bays – one open and the other partitioned. Each of the bays had six beds. The open bay and the central area had a higher ceiling height than the partitioned bay. At the head of each patient bed was a window that was opened for natural ventilation. For this study, the authors applied a pulse-injection gas tracer technique, in which carbon dioxide was used to simulate pathogens. A cluster of three balloons were inflated with CO2 (tracer) and sealed, and remotely pierced to represent/ simulate the sudden release associated with a cough or sneeze. The amount of CO2 in the balloons was kept at a level such that the sensors would not be under- or over-exposed. These balloons were placed either in a central bed or in a corner bed location. Three approaches to ventilation were considered – natural, mechanical (all windows were closed), and no ventilation

DESIGN IMPLICATIONS

When designing wards, the following may be considered:

If natural ventilation is being considered as a viable option, it should be paired with mechanical ventilation.

Partitioning wards

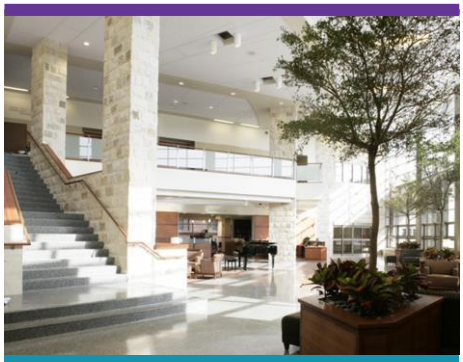
(with closed windows and fans switched off). Five CO2 monitors were used to take readings at intervals of five seconds. The external weather conditions (temperature, wind speed, humidity, and air pressure) were monitored for all experiments.

Findings

These were the findings when the tracer was released from a central bed location:

- In the open bay:
    - Spatial distribution of the tracer was uniform in conditions of natural ventilation and no ventilation.
    - In terms of concentration, there was less uniformity in the two ventilation scenarios. The largest concentration was near the source – at the bedside of the source patient and the adjacent patient; smaller peaks of concentration were measured in the center of the ward, and smaller concentrations were measured at the bedside of the opposite patient. The mean concentration at the bed diagonally opposite the source was over 40% less than that at the source.
- In the partitioned bay:
    - The partitions influenced the distribution of the tracer. In the natural ventilation scenario, it was seen that the exposure at the source was higher in the partitioned bay as compared to the open bay.
    - In the mechanical ventilation scenario, the results were the same as above. In a windows-closed-low-wind scenario, the level of exposure increased across the ward.
    - In terms of concentration, the results were similar to the exposure patterns. In the natural ventilation scenario, the peak concentration was higher than the exposure; in the low wind scenario it was significantly higher than the no-ventilation scenario in the center of the ward.
    - In a no-ventilation scenario, the tracer concentration moved towards beds adjacent to and opposite from the source bed. This did not happen in a natural ventilation scenario.
- Location of source on windward or leeward side of the building:
    - Releasing the tracer on the leeward side of the building reduces exposure at all locations, except at the bed adjacent to the source bed.
    - The concentration of the tracer is lower when the source is on the leeward side, when compared to when the source is on the windward side

These were the findings when the tracer was released from a corner bed location:



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- In the open bay:
  - The exposure in a natural ventilation scenario was slightly higher as compared to the central bed location. In a no-ventilation scenario, there was an increase in exposure across the ward.
  - Tracer concentration was similar to releasing the tracer from a central bed location.
- In the partitioned bay:
  - The partitions affected the distribution and the highest exposure was close to the source and at the opposite bed, but much lower beyond the partitions. In a no-ventilation scenario, there was an increase in exposure across the ward.
  - Tracer concentration was similar to the central bed, with concentration being higher at the source.
- Location of source on windward or leeward side of the building:
  - Locating the tracer source on the leeward side of the building reduced overall exposure in the ward except at the adjacent bed in the case of the open bay.
  - In the partitioned bay, the leeward location reduced exposure at the source and at the opposite bed, but the exposure to the tracer was still greater than at the beds separated by the partitions, whose exposure was not affected by the leeward or windward location of the tracer source when ventilation was natural.

Limitations

The limitations of this study, as indicated by the authors:

- A limited number of experiments were carried out. And because of issues with some of the experiments, some had to be discarded, reducing the total number of usable experiments.
- The study site was a ward that was not in use, and thus not maintained. Since the heat had been turned off in the building, the thermal environment at the time of the experiments was not similar to that of a ward in use.

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